GB1227L52S3 1974

SANTA CLARA VALLEY WATER DISTRICT

LLAGAS CREEK HYDROLOGY

REVIEW OF THE SCS WATERSHED WORK PLAN HYDROLOGY

IN FULFILLMENT OF CONTRACT NUMBER AGD6SCS-00083

By

A. D. Saah
Associate Civil Engineer

And

R. Talley
Assistant Civil Engineer

Under the Direction of

E. Watson
Division Engineer
Resources Development Division

October 1974

John T. O'Halloran
General Manager

Lloyd C. Fowler
Chief Engineer

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Conclusion and Recommendations

In compliance with the contract numbered AG06SCS-00083 between Santa Clara Valley Water District and the Soil Conservation Service, Table 1 shows the results of the review of the SCS LLAGAS CREEK WATERSHED WORK PLAN HYDROLOGY. This table compiles the results that were obtained by the District and compares them with the SCS Work Plan results.

The percentages of deviation, shown in the last column reflect the differences between the results of both studies with an enlarged Chesbro. These differences change from plus to minus at the confluence of Llagas Creek and Rucker Creek. Upstream of Rucker the District values are slightly larger than the SCS values, while downstream of Rucker the opposite is true. Larger District values upstream from Rucker are due to the fact that the District's 1972 M.A.P. values are larger than those used by the SCS (Exhibits 8 and 9). Smaller District values downstream from Rucker were caused by the diversion of the West Branch which is included in the SCS Work Plan (SCS Llagas Creek Watershed Work Plan, Sheet #2), and excluded from the District's review. That diverson was to connect the West Branch from Station 111+00 to Llagas Creek at a point downstream from Rucker. However, that scheme has been abandoned and replaced by the existing channel parallel to the South Valley Freeway.

Considering these basic differences, the results of the two studies are comparable and the differences accounted for. It is

TABLE - 1

Pickup Point	Location	District's 1%* Design Flows c.f.s. Chesbro Existing	District's 1%* Design Flows c.f.s. Chesbro Enlarged	SCS 1% Design Flows c.f.s. Chesbro Existing	SCS 1% Design Flows c.f.s. Chesbro Enlarged	Percent Deviation Enlarged Chesbro
1	U/S of Chesbro Dam	7620	7620			
1	D/S of Chesbro Dam	4370	2580	5750	2380 ✓	8%
2	D/S of Machado Cr. Confluence	5000	3210			
4	W. Little Llagas @ Edmundson	1600	1600			
3	W. Little Llagas @ Llagas	2410	2410			
3	Llagas U/S of W.L. Llagas Confl.	5280	3820		3430 ✓	10%
3	Llagas D/S of W.L. Llagas Confl.	7480	6230 ✓	6620	4920 → 5100	21%
5	U/S of E.L. Llagas Confluence	7230	5970			
5	D/S of E.L. Llagas Confluence	11670	10420	11000	8900 ✓	15%
5	E.L. Llagas @ Llagas	4440	4440			
6	E.L. Llagas D/S of Corrallitos Confluence	3090	3090			
7	E.L. Llagas D/S of San Martin Confluence	3940	3940			
8	Llagas D/S Rucker Confluence	11820	10630		9290 → 10100	13%
9	Llagas D/S Live Oak Confluence	12240	10960			
10	Llagas U/S of Alamias Confl.	12240	10960	11700	13410 10100	-19%
10	Llagas D/S of Alamias Confl.	12560	11300			
11	Llagas U/S of W. Branch Confl.	12430	11230			
11	Llagas D/S of W. Branch Confl.	16620	15520	17100	16140 → 16300	-4%
11	W. Branch U/S of Confluence	4850	4850			
12	W. Branch @ Lions Creek	2040	2040			
12	Lions @ W. Branch Confluence	1530	1530			
12	W. Branch D/S of Confluence	2990	2990			
13	Miller Slough U/S of Confl.	680	680			
13	W. Branch @ Miller Slough Confl.	3250	3250			
14	Princevale Drain @ Confluence	940	940			
14	Llagas D/S of Princevale Confl.	17180	16014			
16	Jones Creek @ Grant Avenue	1100	1100			
17	Dexter Cr. @ Jones Cr. Confl.	500	500			
17	San Ysidro D/S of Jones Confl.	2470	2470			
15	Llagas D/S of San Ysidro Confl.	18670	17550			

*Numbers are rounded up to the nearest ten c.f.s. - See Appendix for hydrographs and other details.

suggested that whatever methodology is followed in the future, the new M.A.P. map should be used.

The choice of final design flows is dependent on the type of flood control projects to be implemented. The District's method of determining design flows, as the word "design" implies, assumes that a system of flood control improvements has been built and no flooding at the one percent level occurs. A floodplain design might change these values if the resulting floodplain has significant storage capacity.

A look at the effect of enlarging Chesbro reveals that a peak flow reduction of up to 73 percent would occur in the upper reaches of the creek, but this is reduced to only six percent near San Ysidro. The reduction of the peak flow in the upper reaches is of less benefit because these reaches are in well defined natural channels and rural areas.

Various studies relating to flood control and water conservation projects are progressing in the watershed. Implementation of any of these projects, such as the Hayes Valley Reservoir (50,000 acre-feet capacity), might require revisions of hydrologic studies of the basin.

It is recommended that the District's values for the 1% design flows should be adopted. This recommendation is based on the following:

1. The District's values were determined based on the existing conditions of the watershed.

2. The effect of future developments can be quickly and easily analyzed by utilizing the same input data that was developed for this study with little effort.

3. The regional approach gives homogeneity to the flood control projects in the South Zone.

Scope and Objectives

The scope of this study is to analyze the 1% flood, and generate design flows that would be completely contained within the channel system. The computation of these design flows will achieve the objective of checking the SCS Work Plan Hydrology. At the 1% flood level, urbanization and agricultural effects are assumed to be negligible, (Ref. 5, 7 and 8).

Watershed Description

The drainage area of Llagas Creek is 103 square miles. Approximately 50 percent of this area today is devoted to agriculture. This is expected to reduce to 40 percent by the year 2000. Urbanization in that year is expected to include only about 20 square miles of this area. The major land use is expected to be mainly low density residential.

The projected population is 46,000 by 1980 and 122,000 by the year 2000 (Master Plan of the In-county Water Distribution System, December 1974).

The mean annual precipitation varies, with elevation from 16 inches at the Pajaro River to 56 inches at Loma Prieta. The elevation of the watershed ranges from 200 feet to 3800 feet above mean sea level.

Methodology

The method that was used in this study is simply the joint application of Clark's unit hydrograph theory and the District's regional frequency analysis. Utilizing the Corps of Engineers'

HEC-1 Program, the unit hydrograph approach was used to generate pattern hydrographs, and the regional equations were used to balance the peaks and the volumes of these pattern hydrographs. The following is a summary of the procedure:

1. Inputs

   a. Subdivide the basin into various subbasins that demonstrate climatological and orographic homogeneity and find the area in square miles. (Exhibit 10).

   b. Compute Clark's synthetic unit hydrograph parameters (T_c & R). (Exhibits 6-7).

   c. Find the 24-hour 1% storm volume for every subarea using the regional equation, and distribute it by the Corps of Engineers Standard Storm.

   $V = P^{0.65}$ (Exhibit 4 and Reference 9)

   where P is the weighted mean annual precipitation of the subarea.

   d. Decide on a duration time ($T_d \leq T_c$), where T_d is the duration time and T_c is the time of concentration.

   e. Assume a constant loss rate of 30% of the total storm. The loss rate, thus assumed, is an approximate value. Optimization of loss rate variables could have been done for an instrumented area of similar characteristics, and a set of loss rate variables could have been obtained. But due to the balancing operation and lack of data, a 30% constant loss rate was found to be satisfactory.

f. Compute the 1% flood peaks and 24-hour volumes for every subarea by utilizing the regional regression equations as devised by the District and discussed below. (Exhibits 1-3).

g. Build a storage-discharge relationship for Chesbro Reservoir under the two conditions, existing and enlarged.

h. Define the Muskingum routing coefficients (k) & (x) for every reach of the channel.

2. Computations

a. From steps (a to e) of item 1, compute inflow hydrographs for all subareas. (Appendix).

b. Balance the results of step (2-a) with the regional peak and 24-hour volumes from step (1-f). (Appendix).

c. Beginning from the uppermost area and going downstream, route and combine various balanced hydrographs. Routing through the reservoir was done by the modified Pulse method and routing through the stream channels was done by the Muskingum method.

3. Regional Frequency Analysis - Santa Clara Valley Water District, in its endeavor to provide equal flood protection for all the people of Santa Clara County, has adopted the regional frequency approach as a criteria for the design of the flood

control projects. The regional frequency theory has proven to be a reliable method for the solution of flood problems and the computation of the design flows of ungaged basins.

For the purpose of developing the regional equation, fifteen streamgage base stations in and around the county were utilized. The climatological, physical and geomorphic characteristics (mean annual precipitation, area, bifurcation ratio, shape factors) of the watersheds of the base stations were correlated with the statistical parameters of their respective streamflow record.

Multiple regression and correlation was done and the following form of equations were defined:

$$M = \log\left(C\ A^{k1}\ P^{k2}\ B^{k3}\ Sh^{k4}\right)$$

$$\sigma = C_1\ A^{j1}\ P^{j2}\ B^{j3}\ Sh^{j4}$$

where M = mean

σ = standard deviation

C & C_1 = regression constants

k_1----k_4 = regression coefficients for the means

j_1----j_4 = regression coefficients for the standard deviations

A = area

P = mean annual precipitation

B = bifurcation ratio

Sh = shape factor

These equations were also reduced to a shorter form utilizing the most predominant physical and climatological parameters, the mean annual precipitation and the area.

$$M = \log (C\ p^{k} A^{k'})$$

$$\sigma = C_1\ P^{j}\ A^{j'}$$

From the above statistical parameters and by utilizing a Pearson's Type III frequency distribution, the projected floods of any frequency will then be equal to the mean plus the standard deviation multiplied by the frequency distribution factor.

$$Q = m + k$$

where Q = projected flow

k = frequency distribution factor

In general, the existing data showed skewed frequency distributions. From the fifteen base stations that were analyzed a regional coefficient of skewness of -.4 is adopted. The following regression equations were the results of the District's regional analysis. It should be noted here that these equations may be changed as more data is acquired. A revision every 5 years is thought to be adequate.

Regression equations for the Peaks:

$$M = \log (1.9258\ A^{.78}\ P^{1.104})$$

$$\sigma = .444\ A^{.03}\ P^{-.018}$$

Regression equations for the 24 Hour Volumes:

$$M = \log (.1808\ A^{.923}\ P^{1.561})$$

$$\sigma = .9718\ A^{-.0007}\ P^{-.197}$$

References:

1. Chow, "Handbook of Applied Hydrology".
2. Santa Clara Valley Water District, "Regional Frequency Methodology, Flood Peaks and Volumes", (unpublished).
3. Corps of Engineers HEC-1 Program.
4. Nash and Show, "Flood Frequency as a Function of Catchment Characteristics", The Institute of Civil Engineering, London.
5. C. W. Richardson, "Changes in Water Yield of Small Watersheds by Agricultural Practices", 1972, Transaction of the ASAE.
6. Leo R. Beard, "Statistical Methods in Hydrology", U. S. Army Corps of Engineers.
7. Epsey and Winslow, "Urban Flood Frequency Characteristics", February, 1974, Journal of the Hydraulics Division.
8. U.S.G.S., "Digital Simulation of the Effect of Urbanization in the Upper Santa Ana Valley", Water Resources Investigations, 41-73.
9. Santa Clara Valley Water District, "Rainfall Depth-Duration-Frequency Regional Study", Unpublished.

Llagas Creek [illegible] % [illegible]

Sub-Area	AREA Sq. Mi	t_c (hrs)	R	$X^{=0}$	K (hrs)	AVG ELEV	1972 M.A.P.	PEAK	REGIONAL FREQUENCY HYDROGRAPH VOLUMES (CFS) 1 HR	2 HR	6 HR	12 HR	24 HR	43 HR	TOTAL RAIN 24 HR
A	19.25	3.6	2.3				32.84	7616	7581	14,850	37,114	64,188	~~[illegible]~~ 67300	99,552	9.68
B	4.92	1.7	1.7				26.57	1925	1909	3724	9432	15168	~~[illegible]~~ 15367	22,0[illegible]	8.45
C	2.77	1.7	1.1				26	1160	1145	2236	5544	8,844	~~[illegible]~~ [illegible]	12,576	8.21
D	5.09	2.0	1.7				22	1619	1604	3126	7914	12,720	~~[illegible]~~ 12,862	18,48[illegible]	7.46
E	2.09	1.6	1.0				24.33	853	842	1630	4026	6372	6413	8976	7.76
F	2.30	2.9	.8				22	830	820	1590	3936	6240	6256	8832	7.46
G	7.89	3.2	1.8				20	2116	2106	4130	10506	17,040	17243	25104	7.01
H	5.71	1.6	2.2				20	1611	1596	3112	7914	12,744	12862	18,576	7.01
I	4.68	1.1	2.1				20	1363	1352	2636	6648	10,668	10733	15,405	7.01
J	2.73	1.1	1.3				20	866	856	1662	4140	6552	6582	9312	7.01
K	3.67	1.0	1.8				20	1111	1099	2134	5352	8568	8615	12,288	7.01
L	3.35	1.0	1.5				19	974	961	1872	4674	7440	7502	10,656	6.78
M	3.24	1.1	1.2				18	894	884	1722	4302	6852	6861	9772	6.55

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DATE:

Exh-1

COMPUTATIONS FOR FLOOD FREQUENCY CURVES

STREAM: Llagas Creek LOCATION: A

$A = 19.25$ sq. miles $P = 32.84$ inches

$$Q_m = 1.92575\,A^{0.78}\,P^{1.104}$$
$$\sigma = 0.44138\,A^{0.03}\,P^{-0.018}$$

(1972 Revised
Regression equation
See [illegible]
Report, Exhibit 1

Or,
$$M = \log Q_m = 0.28460 + 0.78 \log A + 1.104 \log P$$
$$\log \sigma = -0.35225 + 0.030 \log A - 0.018 \log P$$

$M = 2.9606$
$\sigma = .4560$

Expected Prob. P %	K	$K\sigma$	$M + K\sigma$	Q c.f.s.
1	2.02	.9212	3.8818	7616
2	1.83			
10	1.25			
50	0.10			
90	-1.41			

PRELIMINARY

Exh-2

VOLUME COMPUTATIONS

Stream: LLAGAS

Location: Area A

Area = 19.25 Sq. Miles

M.A.P. = 32.84 Inches

24-Hour Volume

Mean, M = $\log\left[.1808\ A^{0.923}\ (\text{M.A.P.})^{1.561}\right] =$ 2.8098

Standard Deviation, $\sigma = .9718\ A^{-0.007}\ (\text{M.A.P.})^{-0.197} =$ .4785

Expected Probability %	K Skew= -0.5	Kσ	M + Kσ	Vol=10 (AF) $^{M+K\sigma}$	Volume CFS-HR
1	1.955	.9354	3.7452	5562	2804
2	1.777				
10	1.216				
50	0.083				
90	-1.323				

PRELIMINARY
[illegible] TO [illegible]

48-Hour Volume

Mean, M = $\log\left[.2410\ A^{0.930}\ (\text{M.A.P.})^{1.585}\right] =$

Standard Deviation, $\sigma = 1.0024\ A^{0.0005}\ (\text{M.A.P.})^{-0.21226} =$

Expected Probability %	K Skew= -0.5	Kσ	M + Kσ	Vol=10 (AF) $^{M+K\sigma}$	Volume CFS-HR
1	1.955				
2	1.777				
10	1.216				
50	0.083				
90	-1.323				

(1972 Revised Regression Equations)

Exh-3

By________ Date July 74 Chkd. By________ Date________ Sheet No.____ of____

Subject Llagas Creek Watershed Job No.________

24 hr. Storm

Sub-Area	M.A.P. (P)	100 yr	50 yr	25 yr	20 yr	10 yr	5 yr
		$1.0\ P^{0.65}$	.907 × 100 yr	.810 × 100 yr	.777 × 100 yr	.680 × 100 yr	.590 × 100 yr
A	32.84	9.68					
B	26.57	8.43					
C	26	8.31					
D	22	7.46					
E	24.33	7.96					
F	22	7.46					
G	20	7.01					
H	20	7.01					
I	20	7.01					
J	20	7.01					
K	20	7.01					
L	19	6.78					
M	18	6.55					
N	24	7.89					

PRELIMINARY

Exh-4

TABLE 5
24-HR STANDARD PROJECT GENERAL STORM*
PRECIPITATION BY PERIODS IN PERCENT OF TOTAL

Period	Total storm precipitation in inches								
	0 to 5.74	5.75 to 6.92	6.93 to 8.06	8.07 to 9.17	9.18 to 10.23	10.24 to 11.27	11.28 to 12.25	12.26 to 13.22	13.23 plus
1	1.57	1.59	1.61	1.63	1.66	1.68	1.71	1.74	1.77
2	2.35	2.38	2.42	2.29	2.32	2.36	2.40	2.43	2.30
3	2.19	2.23	2.10	2.13	2.16	2.02	2.05	2.09	2.12
4	3.14	3.18	3.39	3.44	3.49	3.54	3.42	3.30	3.36
5	4.23	4.28	4.19	4.26	4.32	4.22	4.28	4.35	4.25
6	3.60	3.66	3.71	3.76	3.66	3.71	3.77	3.65	3.72
7	3.14	3.18	3.23	3.27	3.32	3.37	3.25	3.30	3.35
8	3.76	3.65	3.71	3.76	3.82	3.88	3.94	4.00	3.89
9	3.76	3.82	3.87	3.76	3.82	3.71	3.77	3.83	3.89
10	3.29	3.34	3.39	3.44	3.49	3.54	3.60	3.65	3.72
11	3.29	3.34	3.39	3.44	3.49	3.54	3.60	3.65	3.72
12	3.60	3.66	3.71	3.76	3.82	3.88	3.94	4.00	4.07
13	3.76	3.82	3.87	3.93	3.98	4.05	4.11	4.18	4.25
14	5.65	5.72	5.64	5.73	5.82	5.90	5.82	5.74	5.84
15	4.23	4.13	4.19	4.26	4.16	4.05	4.11	4.18	4.07
16	6.74	6.63	6.61	6.39	6.31	6.24	6.16	6.08	6.02
17	6.59	6.52	6.29	6.22	6.15	6.07	5.99	5.91	5.84
18	12.39	12.08	11.77	11.46	10.95	10.62	10.28	9.74	9.35
19	4.70	4.61	4.67	4.58	4.65	4.73	4.62	4.70	4.60
20	4.23	4.28	4.36	4.42	4.47	4.56	4.62	4.70	4.78
21	3.60	3.66	3.71	3.76	3.82	3.88	3.94	4.00	4.07
22	3.45	3.50	3.39	3.44	3.49	3.54	3.60	3.65	3.72
23	3.45	3.50	3.55	3.60	3.40	3.54	3.60	3.65	3.72
24	3.29	3.18	3.23	3.27	3.32	3.37	3.42	3.48	3.54

*Adopted from "Standard Project Rain-Flood Criteria", Sacramento-San Joaquin Valley, California, U.S.Army Corps of Engineers, Sacramento, California, April 1957 (Revised 1958)

100 year	1.000
50 year	.907
25 year	.810
20 year	.777
10 year	.680
5 year	.580

Exh-5

By ______ Date ______ Chkd. By ______ Date ______ Sheet No. ______ of ______

Subject ______ Job No. ______

DETERMINATION OF CLARK'S CONSTANTS

Sub-basin no. A ; Area, A = 19.25 sq. miles.

Length of the main stream, L = 61,600 feet = 11.67 miles.

Elevation difference, h = ( ) − ( ) = 775 feet.

Effective slope, $S = \frac{h}{L} = \frac{(775)}{(11.67)}$ = 66.43 feet/mile.

$L/\sqrt{S} = \frac{(11.67)\text{ miles}}{(8.15)\sqrt{\text{feet/mile}}}$ = 1.43 (mile$^{3/2}$/feet$^{1/2}$)

From the chart, $L/\sqrt{S}$ vs TC (Clark's)

Values of TC, Upper limit = 5.2 hours.

Lower limit = 2.1 hours.

Therefore, Mean = 3.65 hours.

$T_c = .0078\left(\frac{L^{3/2}}{H^{1/2}}\right)^{.77} + 10_{min}$ 3.58 $\boxed{3.6}$

Now,

Average Width of the basin = $\frac{A}{L} = \frac{(19.25)}{(11.67)}$ mile

= 1.65 mile.

PRELIMINARY

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DATE

From the chart, Width vs R (Clark's)

Values of R, Upper limit = 3.5 hours.

Lower limit = 1.1 hours.

Therefore, Mean R = 2.3 hours.

RTIOL = 1·50 ; CP = TP = 0·

RTIOR = 1·90 ; TR = 60·00 minutes.

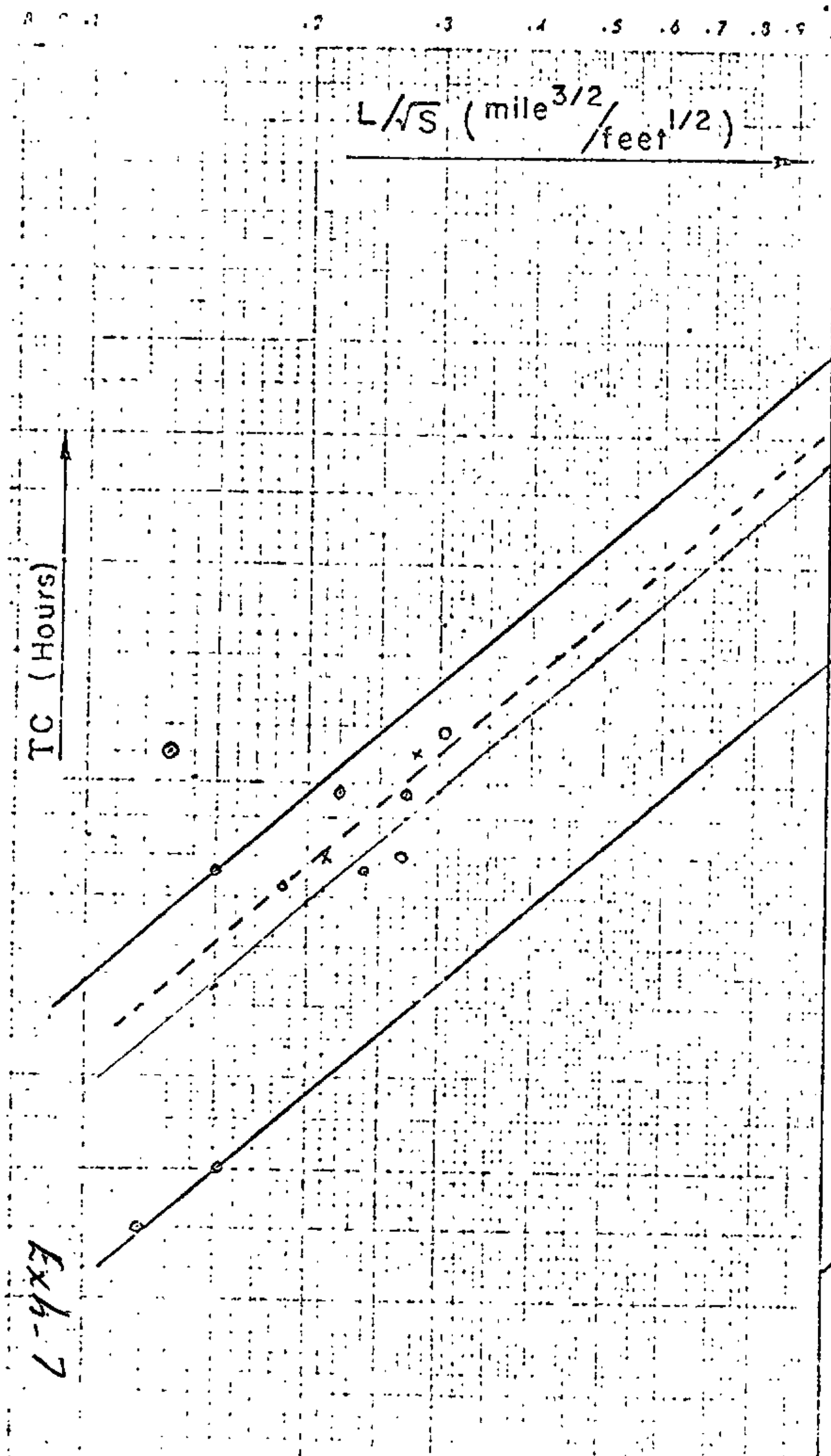
Rate of loss, E = 0·5

QRCSN = RCVRY = 0·0

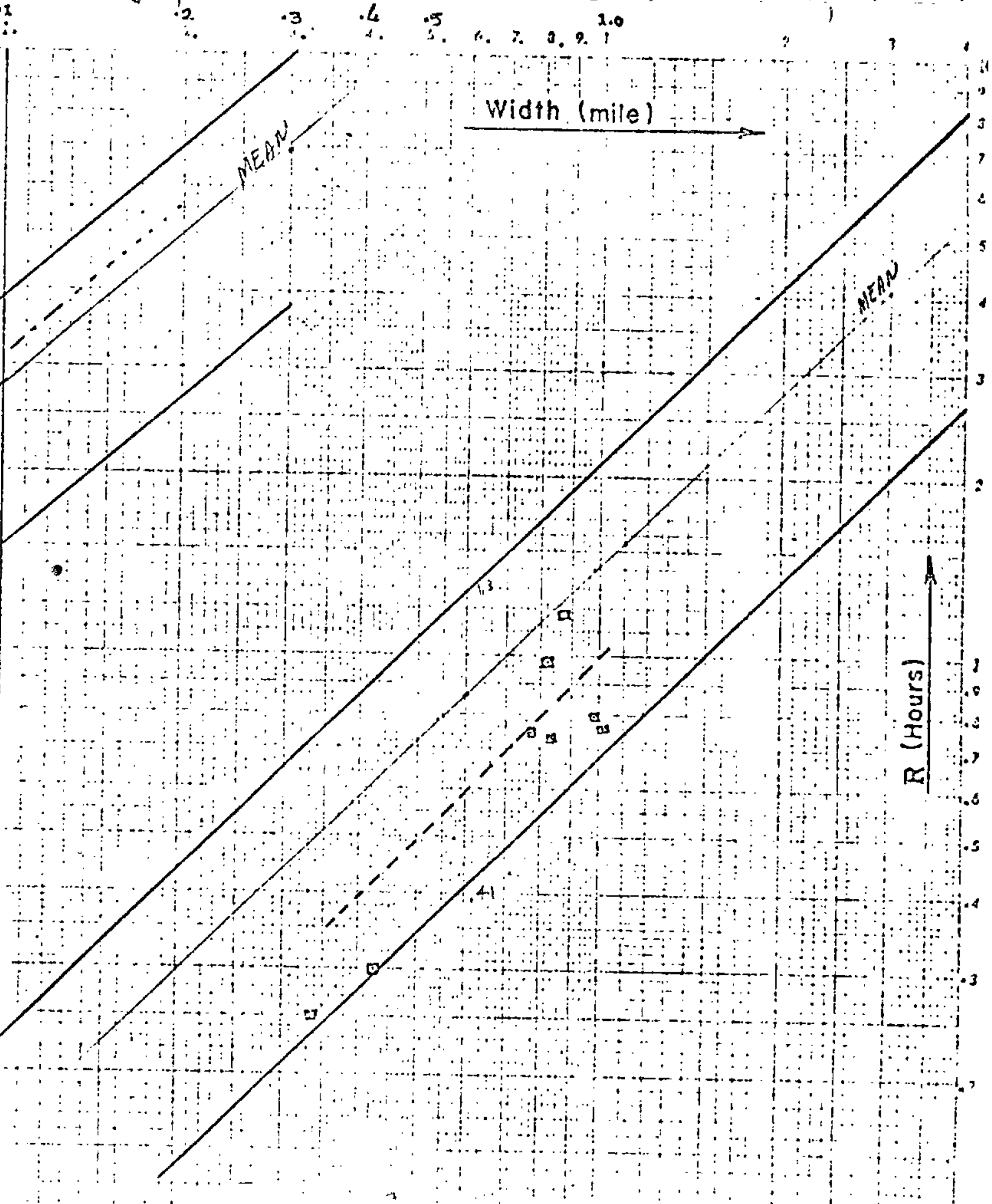
RTIMP = ______ Urbanization effect.

Exh-6

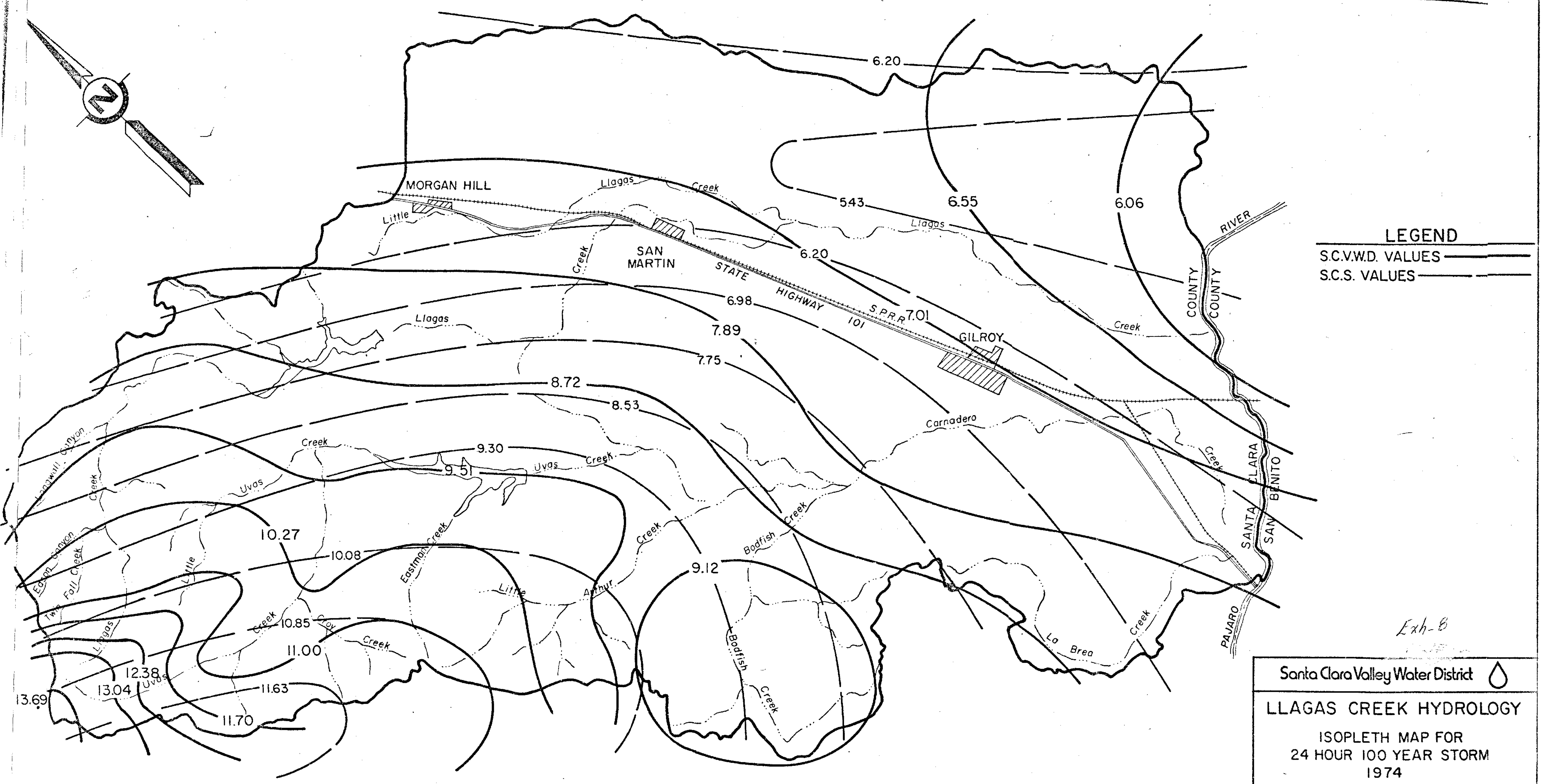
Ex4-7



L/√S vs TC (Clark's)



Width vs R (Clark's)

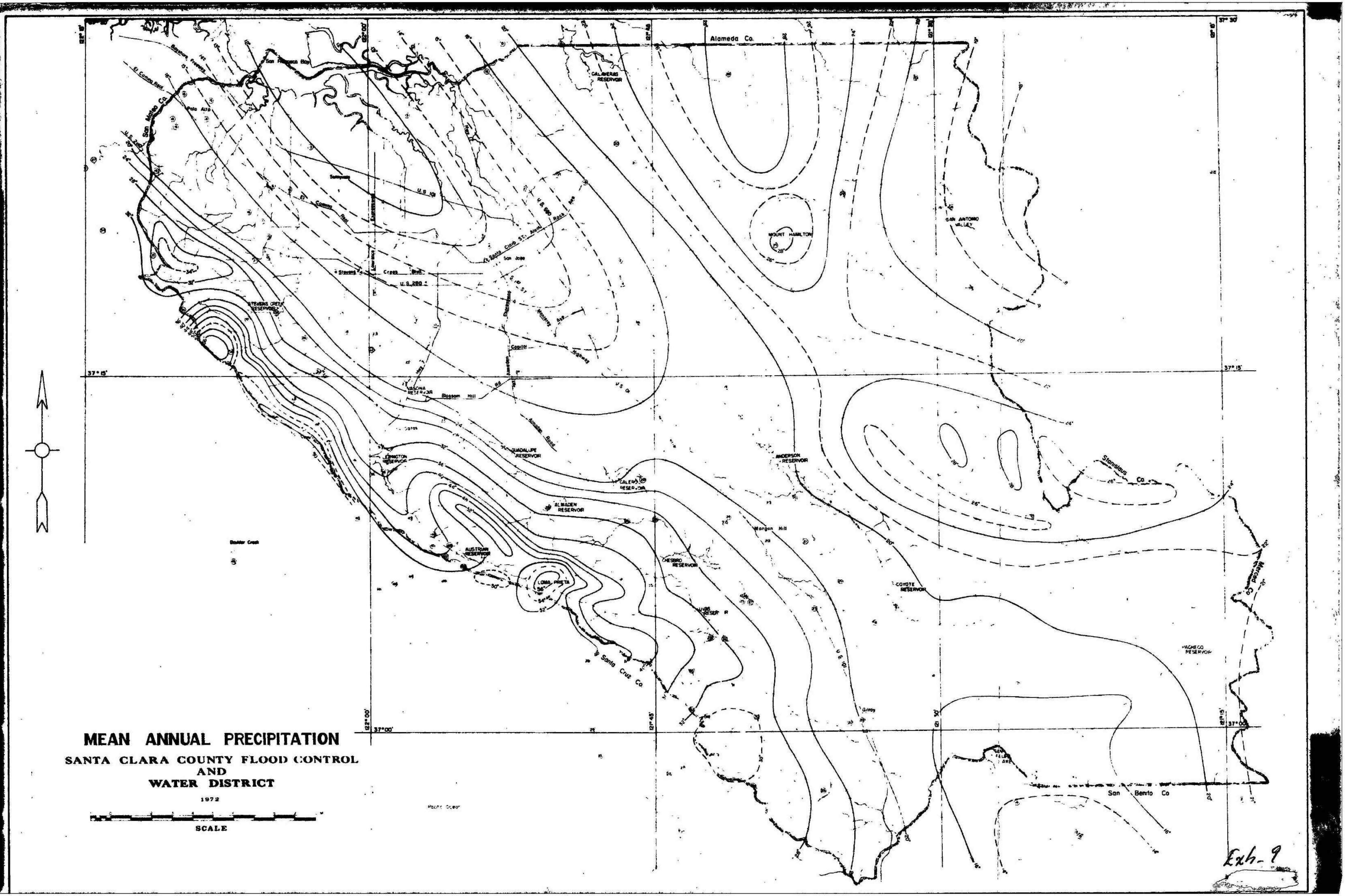


Santa Clara Valley Water District

LLAGAS CREEK HYDROLOGY

ISOPLETH MAP FOR
24 HOUR 100 YEAR STORM
1974

Exh-8



MEAN ANNUAL PRECIPITATION

SANTA CLARA COUNTY FLOOD CONTROL
AND
WATER DISTRICT

1972

SCALE

Exh. 9

LLAGAS CREEK WATERSHED

DRAINAGE AREAS & DISCHARGE PICKUP POINTS
Llagas Creek at Pajaro River = 103.7 Sq. Miles
Llagas Creek at Chesbro Dam = 19.3 Sq. Miles

LLAGAS CREEK HYDROLOGY STUDIES
AUGUST 1974

Exh-10